

# Multipass Sharpening

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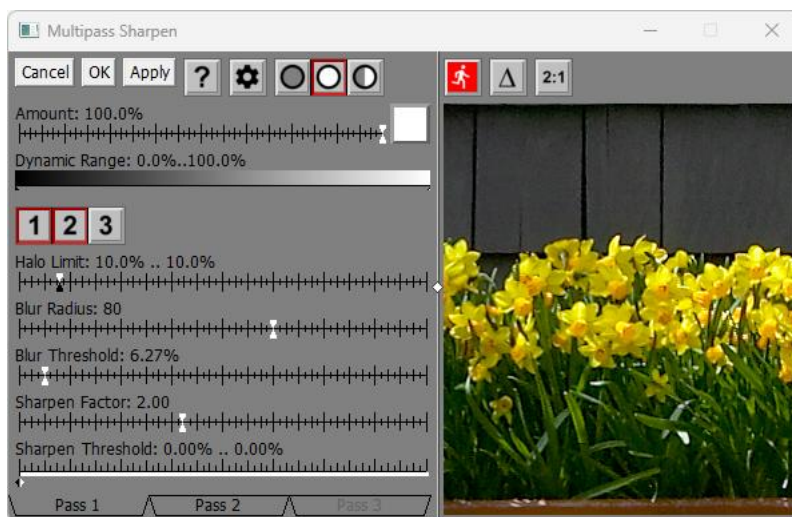
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# Introduction

Multipass Sharpening is a powerful tool for bringing out different levels of detail in images. When applied to fine detail, the process is called sharpening. When applied to larger features, the same process is called local contrast enhancement. Either way the goal is to make parts of the image stand out from whatever surrounds them. By supporting up to three sharpening passes into a single transformation, Multipass Sharpening lets you sharpen an image at several different scales in a single operation.

**Note:** Some of the examples in this document have been sharpened more than normal to illustrate how the transformation works. In practice, the ideal amount of sharpening depends on how an image is viewed – whether on-screen or printed. In addition, the image size, resolution and viewing distance all influence what amount of sharpening looks best. Unfortunately, there is no substitute for trial and error. If, for example, you are sharpening for printing at 8" x 10", you may need to make several test prints with different amounts of sharpening to see which looks best.

## The Multipass SharpenTransformation



The Multipass Transformation's menus, buttons and sliders can be a little intimidating at first. For details on what all the controls are and each one does, please see the help file or Transformations.pdf. Although it breaks down the function of each slider in some detail, this document is less about what the controls are and more about how the underlying transformation works and how to use it effectively to get the results you want.

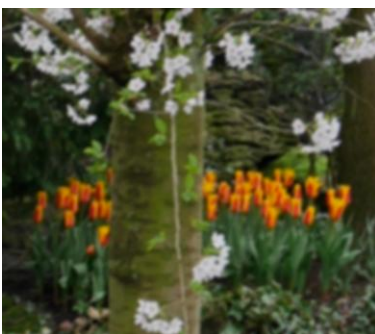
## How Sharpening Works

Sharpening is essentially a two-step process. The first step is to create a blurred version of the input image. The second step is to compare the input image with the blurred version a pixel at a time to produce a sharpened image by lightening the input image where it is brighter than the

blurred image and darkening it where it is darker, thus exaggerating the differences between the two images and making details more prominent.



Original



Blurred

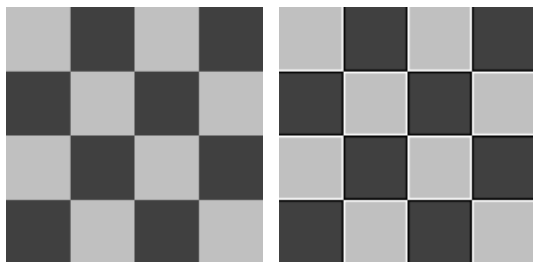


Sharpened

While it may look like sharpening is creating new details that did not already exist in the original image, it is really just making them easier to see. The technical term for this apparent sharpness is acutance, so to be precise, the transformation actually increases the acutance of images and not their sharpness.

## Halos and Edge-Preserving Filters

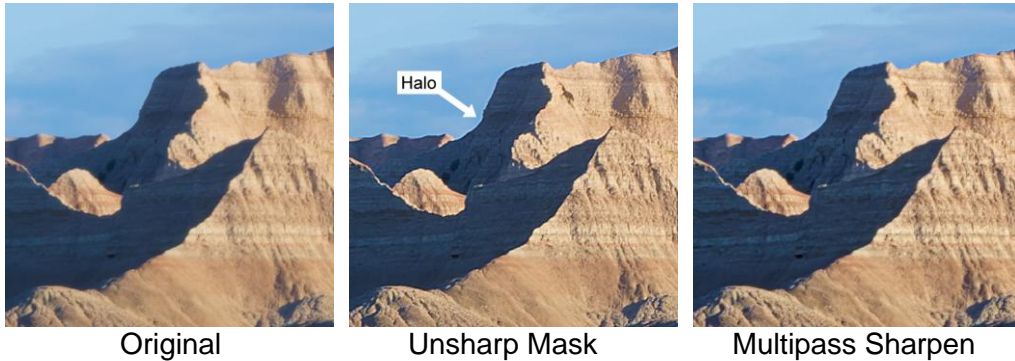
The simplest version of sharpening starts by blurring the input image uniformly using something like a Gaussian blur which is in fact the basis of the Unsharp Mask transformation. The biggest problem with Unsharp Mask can be summed up in one word: *halos*. When sharp edges between light and dark areas in the input image are exaggerated, the light side of the edge becomes white or very light while the dark side of the edge turns black or very dark. These light and dark outlines around edges are called halos, and they limit how much you can sharpen an image before it starts to look unnatural. The heavier the sharpening, the more obvious the halos.



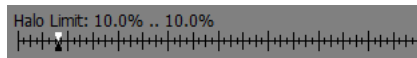
Halos occur because the blurring step bleeds colors across strong edges – if there was a way to blur an image that preserved these edges, we could sharpen images with fewer halos. In fact, a lot of research has gone into inventing exactly these kinds of blurring methods which are called edge-preserving filters. Two examples are the bilateral filter and more recently the guided filter.

Multipass Sharpening incorporates both these blurring methods so you can select whichever one you prefer via the Settings Menu. The results of the two filters are very similar, but the guided filter is faster when blurring with a large radius and produces fewer artifacts.

Here is an example illustrating how Multipass Sharpen can sharpen an image while producing fewer halos than Unsharp Mask.



Like Picture Window's other sharpening transformations, Multipass Sharpen also has a halo suppression double slider. This slider lets you further reduce halos by limiting how much lighter or darker than the input image the sharpened image is allowed to get.

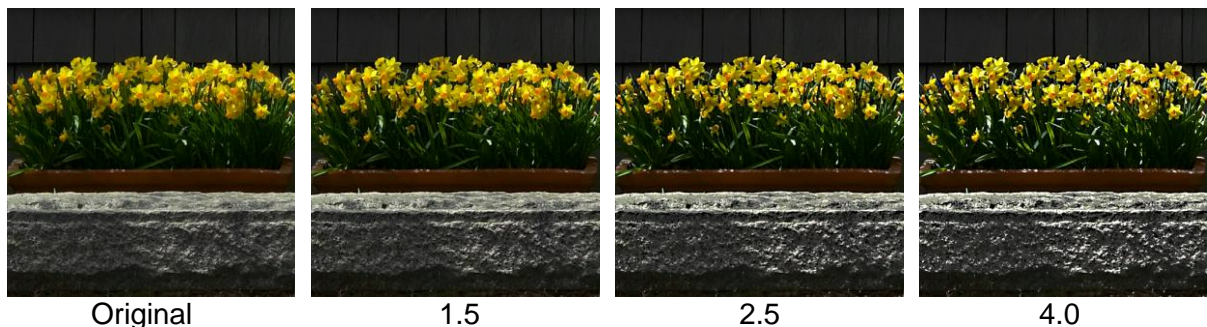


Too small a halo limit reduces the overall sharpening effect. Too large a value does not suppress halos. The defaults of roughly 10% are usually a reasonable compromise. Since light halos are more annoying than dark ones, you could consider setting the black halo slider a little higher than the white one.

## Sharpen Factor

The degree of sharpening is controlled by the Sharpen Factor. Differences between the input and blurred images are multiplied by the sharpen factor, so the larger it is, more strongly details are amplified. Thus, adjusting the Sharpen Factor is the most direct way to increase or decrease the sharpening effect.

If you go too far and over-sharpen an image it will start to break up and look unnatural and may also create clipped highlights or shadows. Here are examples of what happens as you increase the sharpen factor:



# Sharpening and Noise

In addition to making fine detail stand out, sharpening has the unfortunate side-effect of amplifying noise which, after all, is just fine detail. This can be objectionable, especially when sharpening images that have otherwise smooth areas of solid color or gradients, such as skies. Here is an example of a scanned film image where sharpening makes the film grain much more apparent in the sky area.

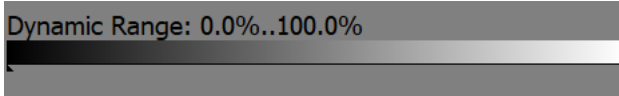


There are several strategies for reducing sharpening noise.

- Use a mask to avoid sharpening areas such as skies that you don't want to sharpen. This works well but depending on the image it can be a lot of work to create a good mask.
- Use the Sharpen Threshold slider (more on this later). This works by only exaggerating differences between the input and the blurred images if they exceed a certain amount, leaving very subtle detail such as noise unsharpened while more prominent detail is sharpened. This method works well with small radius settings which tend to amplify noise with fine texture. For large radius settings leave the Sharpen Threshold at 0%.
- Use noise reduction software prior to sharpening the image. Modern raw converters now incorporate high quality noise reduction algorithms that can perform miracles even on high ISO images. But be careful – overly aggressive noise reduction removes image detail along with the noise.

## Dynamic Range


Sharpening often lightens highlights and darkens shadows, so even if no pixels in the input image are clipped, the output image may have clipped pixels. Clipped dark pixels lead to a loss of shadow detail while clipped highlights cause a loss of highlight detail. To avoid this, you can reduce the dynamic range of the input image prior to sharpening using the Dynamic Range slider.



Moving the white marker left darkens the highlights while moving the black marker right lightens the shadows. Usually only very small adjustments are necessary.

You can detect clipping in the output image using the Display Clipped Pixels tool bar in the main tool bar or by using the Histogram button in the main tool bar.



Whichever one you use, be aware that until you click  to compute the entire output image, the histogram and clipping indicators are not updated.



# Enabling and Disabling Passes

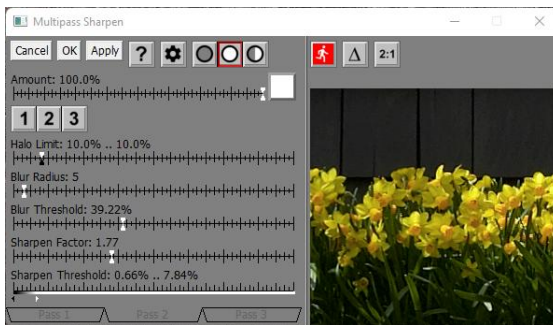
The pass enable/disable tool bar lets you quickly turn on or off any of the sharpening passes.



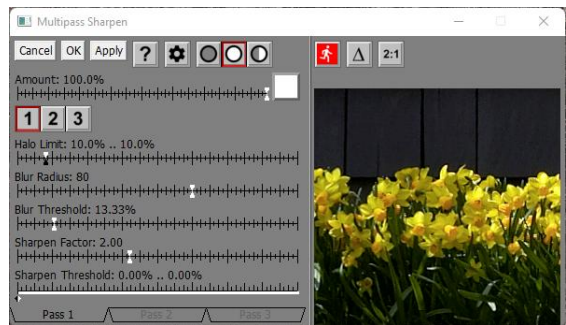
For example, to do single pass sharpening enable the first pass and disable the others.

This tool bar also lets you see the effects of each pass by watching how the preview changes when you turn it on or off. Note that this tool bar operates independently of the tabs at the bottom of the dialog box which simply switch among the settings for each pass but do not affect the preview or output.

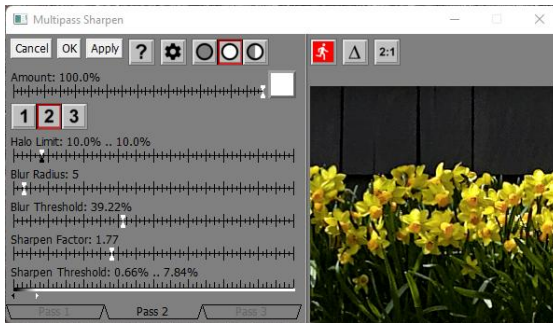
Here are some examples of using the tool bar to turn sharpening and local contrast enhancement on and off:



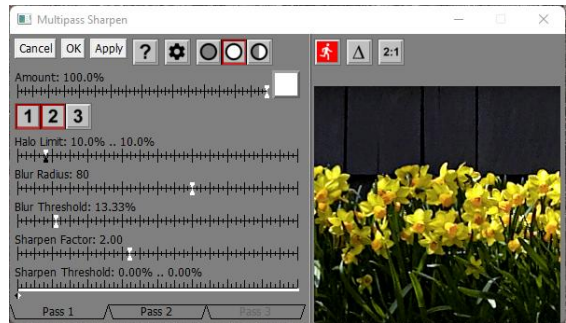
No Sharpening



Local Contrast Enhancement Only



Sharpening Only



Both



# Adjusting the Blur and Sharpen Threshold Sliders

To get the best results from Multipass Sharpening you need to understand what the Blur and Sharpen Threshold sliders do and how to adjust them.

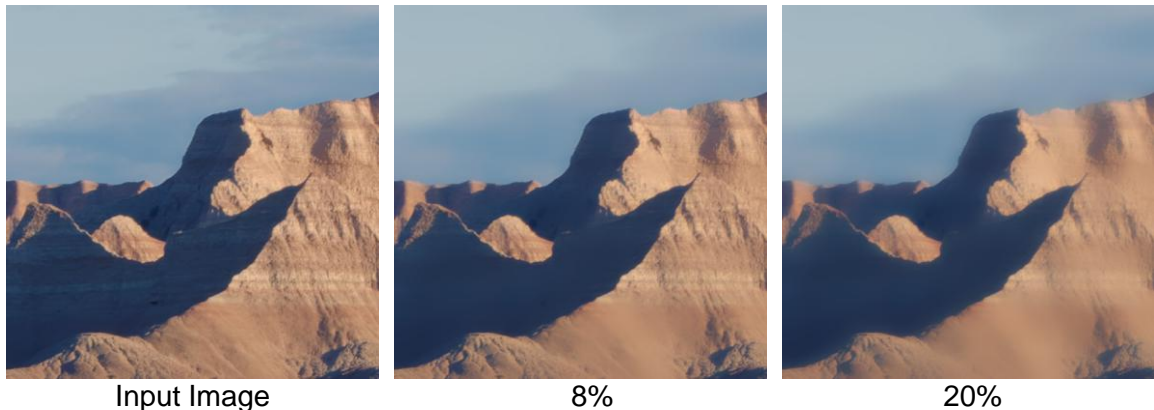
## Blur Threshold

As you might expect from the name, the Blur Threshold affects the way the input image is blurred prior to sharpening. This blurring is done using either a bilateral or guided filter, depending on which you select although they both produce similar results.

As illustrated below, you can see what the blurred version of the input image looks like by setting the Sharpen Factor slider to 0% – this exposes the inner workings of the transformation and can give you some insight into how it works.

A blur threshold of 0% eliminates all blurring and consequently the blurred image is just a copy of the input image, and this in turn suppresses all sharpening. A blur threshold of 100% blurs the entire input image more or less uniformly, so the edge-preserving property of the filter is lost and there is no halo reduction although the entire image is sharpened. Increasing the threshold blurs progressively coarser detail.

Here are some examples of different blur threshold settings for a Blur Radius of 10 pixels. The areas that are blurred the most correspond to where sharpening will be the strongest.



Larger Blur Thresholds sharpen more of the image, but also generate more halos. So, one way to adjust this slider is to set it to the largest value that does not produce objectionable halos. You can then use the Sharpen Factor slider to fine tune the sharpening effect and make it stronger or weaker.

The effect of the Blur Threshold depends heavily on the Blur Radius as well as the nature of the image, so there is no best value for all situations. For small radius settings start with larger blur thresholds (30-40%). For larger radius values, smaller blur threshold settings (5-10%) usually work better.

## Sharpen Threshold

The Sharpen Threshold is basically a way to reduce noise, useful primarily when sharpening with a small Blur Radius. When using a large radius, it is often best to leave the Sharpen Threshold at 0%. For small radius sharpening, values around 0% to 7% usually work well.

A Sharpen Threshold of 0% causes the entire image to be sharpened. As you increase the value (by dragging the slider to the right), progressively coarser detail remains unsharpened. Too small a value may not reduce noise while too large a value may blur the very details you are trying to bring out, so try to use the smallest value that removes the noise.

This setting uses a specialized Threshold Slider control. By adjusting its black and white sliders you can soften the transition from sharpened to unsharpened regions, reducing any artifacts that might otherwise result from a sharp cutoff. For more details on using Threshold Sliders, see Controls.pdf or the help file.

Here is an example of using the Sharpen Threshold to suppress noise from film grain in a scanned image:



Original



0%



5%

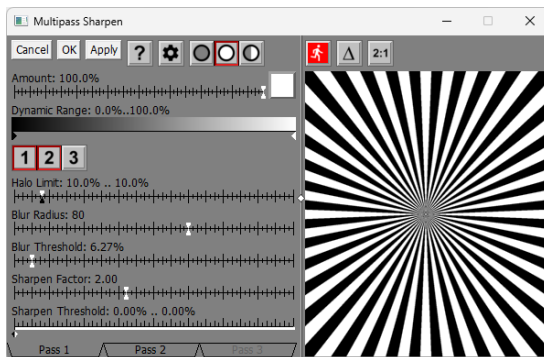
# Two Pass Sharpening

The Blur Radius determines the scale of detail that is sharpened. To bring out fine detail, use a small radius. To bring out coarser detail, use a larger radius.

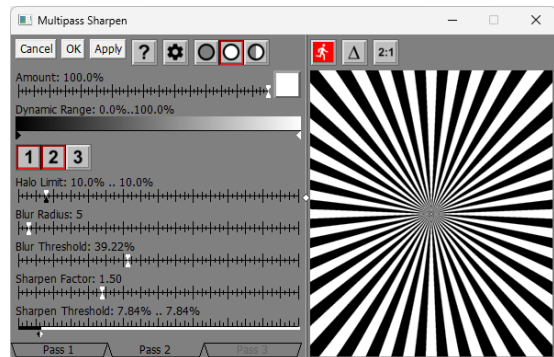
Using a relatively large radius performs local contrast enhancement. This increases the contrast of an image in a way that applying a curve cannot, since it lightens or darkens parts of the image according to what surrounds them. The effect of local contrast enhancement is similar to using Adobe's clarity slider or DxO's micro-contrast slider, but it lets you control the scale of detail that is enhanced.

## Typical Settings

Here are some typical settings for 2-pass sharpening that combine local contrast enhancement with sharpening of fine detail:



Pass 1 - Local Contrast Enhancement



Pass 2 - Sharpening

You can establish these settings by loading the settings file distributed with Picture Window named *Two Pass.multipass sharpen* via the Settings menu. If you want, you can also make these your default settings via the Settings menu. The settings for Pass 3 do not matter since it is disabled.

## How to modify the sharpening effects

The Pass 1 settings affect the sharpening of coarse detail. You can adjust the Pass 1 Blur Threshold based on the strength of the local contrast enhancement you want to produce. Increasing the Blur Threshold increases the effect. Similarly, varying the Pass 1 Sharpen Factor can also be used to fine tune the result. The Blur Threshold determines how much of the image is sharpened while the Sharpen Factor determines how much.

The Pass 2 settings affect the sharpening of fine detail. Varying the Pass 2 Sharpen Factor is main way to alter the strength of the effect.

Turning Pass 1 or Pass 2 on and off using the Pass Enable/Disable tool bar and noting the effect on the preview is a good way to see what each pass is doing to the image.

## Example



Original



Local Contrast Enhancement



Local Contrast Enhancement + Sharpening



## Amount Masks

You may find that different parts of an image benefit from different types or amounts of sharpening. The best way to deal with this situation is to use a sequence of Multipass Sharpen transformations, each with its own Amount mask to isolate a specific area and with settings appropriate to that area. For example, in landscapes, you may or may not want to sharpen the sky the same way as the foreground.



Original



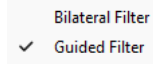
All sharpened



All but the sky sharpened

# Bilateral vs Guided Filtering

The Multipass Sharpen transformation gives you the choice of blurring using a bilateral filter or a guided filter. You can select the one you want to use via the Settings Menu.



The newer guided filter option is recommended for two reasons:

- 1) The guided filter is generally faster than the bilateral filter when using a large blur radius. Since local contrast enhancement requires a large radius, this can make a big difference in processing speed.
- 2) The bilateral filter can cause artifacts in certain cases when sharpening smooth gradients. Most of the time you can fix the problem by adjusting the blur threshold, but not always. Here is a rather extreme example – the original image is a small area cropped from the sky of a much larger photograph. The settings in both cases were identical except for the choice of filter.



Original Image



Bilateral Filter



Guided Filter



## Examples

The image on the left is an infrared photograph processed to remove a hot spot and adjust its brightness curve. The image on the right is the result of applying Multipass Sharpen for both sharpening and local contrast enhancement. Note how this brings out detail in all parts of the tonal range (sharpening) and improves the separation of each element of the image from all the others (local contrast enhancement).



Sometimes sharpening the sky along with the rest of the image produces an interesting effect. The first two images show how Multipass Sharpen can bring out detail in clouds and make them more dramatic and painterly. Subsequent tonal adjustments were able to recover shadow detail in the trees and water. Then some cropping and a little cloning produced the final image.



